REMARKS

Claims 19-53 are pending in the subject application prior to entry of this amendment. Of those claims, claims 30-37 are withdrawn as a result of a restriction requirement and claims 19-29 and 38-43 are rejected. More specifically, claim 38 is rejected under 35 U.S.C. § 112, second paragraph, as being indefinite. Claims 19, 20, 26, 28, 29 and 38-53 are rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent 6,136,682 to Hegde et al. and, alternatively, under 35 U.S.C. § 103(a) as being obvious in view of Hedge et al.

Claims 21 and 23-25 are rejected under 35 U.S.C. § 103(a) as being obvious over Hegde et al. as applied to claim 20, and further in combination with U.S. Publication 20030227068 by Li. Claims 19, 20 and 22 are also rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Publication 20040026119 by Chen. Claim 27 is rejected under 35 U.S.C. § 103(a) as being unpatentable over Hegde et al. as applied to claim 20, and further in combination with U.S. Patent 6,828,189 to Igarashi.

The foregoing rejections are respectfully disagreed with, and are traversed below.

Claim 38 has been further clarified to recite "the films" in line 3. Thus, the Examiner's rejection under 35 USC § 112, second paragraph, should be reconsidered and withdrawn.

Independent claim 19 has been further clarified to specify that each sub-layer has a

thickness of about 0.4 to about 1.5 nm. This claim has also been clarified to specify that the sub-layers are comprised of alternating layers of at least two different materials and the at least two materials selected to comprise the sub-layers are substantially immiscible and exhibit mutual adhesion, wherein the at least two different materials exclude TiN and TaN, and the overall thickness of the barrier is between about 30 and 50 angstroms.

Support for the foregoing exists in the specification as follows: Page 6 discloses that conventional diffusion barrier materials include TiN and TaN. However, copper is able to diffuse through the grain boundaries 215 in these materials 230 and 235. The next paragraph of the specification details acceptable materials for Applicant's alternating layers of materials.

Pages 7-8 of the specification disclose the unexpected benefit of employing 0.4-1.5 nm thick sub-layers. As disclosed therein, the resulting structure has the form of an essentially or substantially amorphous material thereby beneficially inhibiting diffusion through the material. Page 8 also specifies that the overall thickness of the barrier is preferably between 30 and 50 angstroms.

Pages 9-10 of Applicants' specification further discloses that two considerations include that the two materials are preferably immiscible or have at most only a very minor level of solubility, and preferably exhibit good mutual adhesion.

Claims 21-27 depend from claim 19 and recite further advantageous features of the

claimed diffusion barrier.

Independent claim 38 has also been further clarified to specify that the each film is in a range of about 0.4 to about 1.5 nm, wherein the films are comprised of alternating layers of at least two different materials and the at least two materials selected to comprise the films are substantially immiscible and exhibit mutual adhesion, wherein the at least two material exclude TiN and TaN.

Similarly, independent claims 41 and 44 have been clarified to specify a sub-layer or film thickness of about 0.4 to about 1.5 nm each and that the sub-layers or films exclude TiN and TaN. Claim 41 also specifies that each of the sub-layers is comprised of a metal and thus claim 42 is canceled. Claim 44 further specifies that at least one of the materials is a dielectric material and thus claim 50 has been canceled.

Support for the foregoing clarification is, for example, as described above for claim 19.

Claims 47-49 and 51-53 depend from independent claim 44 and recite further advantageous features of the claimed structure.

Regarding the rejections based upon art, it is respectfully asserted that the cited references, whether viewed alone or in any combination, do not disclose nor suggest the subject claims for at least the following reasons.

In particular, Hegde et al. disclose a <u>TiN layer</u> deposited over a <u>TaN layer</u>. A copper material is then deposited over the TiN layer (Abstract). As further disclosed at col. 3, lines 59-67, 0-200 angstroms define the TiN amorphous barrier region and 200-400 angstroms define the TaN or TaSiN layer. Preferably, the TaN or TaSiN layer is between 20 angstroms and 200 angstroms, as disclosed at col. 4, lines 42-52. At col. 2, line 65- col. 3, line 5, Hegde et al. state that the TaN "deposits in an amorphous state" and at col. 4, lines 48-53 Hedge et al. refer to physical vapor deposition.

The subject claims do not relate to TiN/TaN deposition as in Hedge et al., and thus Hedge et al. do not disclose or suggest any of Applicants' claims. Moreover, although Hedge et al. mention amorphous deposition, there does not appear to be any teachings as how to achieve amorphous deposition and thus Hedge et al. is not sufficiently enabling.

Additionally, at col. 3 Hedge et al. cite experiments and assert that there is an <u>unexpected benefit of a 400 angstrom composite</u> of TiN and TaN. In contrast, Applicants claim a thickness between about 30 and about 50 angstroms (see, e.g., claim 1), which is significantly less than that of Hedge et al.

Applicants again respectfully assert that unexpected results are present as a result of the claimed invention. For example, in contrast to Hegde et al. and as disclosed in the specification at page 4, Applicants have determined how to form a very thin, multilayer diffusion barrier composed of even thinner sub-layers, where the sub-layers are only a few atoms thick. A strong bond between each of the sub-layers perturbs the

regular crystalline structure of the sub-layer, as long as the sub-layer remains very thin. Since the surface energies dominate the bulk binding energies, the sub-layer remains disordered and essentially free of a regular crystalline structure. The lack of formation of a lattice within each sub-layer results in no grain boundary formation, and hence, no pathways for inter diffusion through the barrier.

Hegde et al. do not disclose or suggest such a barrier including, for example, each sub-layer having a specific thickness between about 0.4 and about 1.5 angstroms, wherein formation of crystalline lattice and diffusion of a chemical species through the barrier is inhibited. Hegde et al. particularly teach that "unexpected results" are obtained with a 400 angstrom composite. There is no description in Hedge et al. of the claimed structure at the claimed nanometer scale. Hegde et al. discloses TiN deposited over TaN, which is not the same as, nor suggests, Applicants' claimed structure, which particularly excludes such types of sub-layers.

Nor does this reference disclose or suggest the claimed multilayer diffusion barrier including the afore-referenced film thickness, wherein the surface adhesion of each interface inhibits the formation of a lattice in the individual film layers inhibiting diffusion across the barrier, or comprising alternating films of at least two different metals wherein work hardening is substantially eliminated. Nor is the particularly claimed multilayer structure of the claimed thickness disclosed or suggested.

The addition of Li et al., Chen and/or Igarashi does not cure the shortcomings of Hegde et al. for at least the following reasons. Li et al. relate to a sputtering target.

While Li et al. may generally mention a grain size less than 1 nm, Li et al. do not disclose or suggest any structure including the particularly claimed thin layers, wherein formation of a crystalline lattice is inhibited.

Chen discloses a semiconductor device including a barrier layer comprising an amorphous metallic glass. Chen does not disclose any structure as claimed herein including the specified sub-layers. Paragraph 25 of Chen describes an amorphous metallic glass barrier and its effect on surface free energy, which allows the next layer deposited to be <u>more textured</u>. In paragraph 26, Chen discloses a layered structure of the preferred layer of amorphous metallic glass and additional layers of a variety of compounds of nitrides and carbides, which do not appear to be described as amorphous.

Lastly, Igarashi relates to <u>the blocking of hydrogen</u> diffusion with the use of oxide films and was particularly cited by the Examiner as disclosing tantalum oxide. This disclosure in combination with any/all of the afore-cited references does not disclose or suggest the claimed invention for the reasons set forth above.

In view of the foregoing, it is asserted that there is no teaching or suggestion that would motivate one of ordinary skill in the art to combine and modify the cited references in an attempt to arrive at the subject claims. Without such a teaching, suggestion or motivation, the invention may only be considered obvious in hindsight, which is an improper basis for rejection.

All issues having been addressed, the subject patent application is believed to be in condition for immediate allowance. No new issues requiring a further search are presented and thus the Examiner is requested to enter and consider and Amendent. Accordingly, the Examiner is respectfully requested to reconsider and remove the outstanding rejections and objection. An early notification of the allowance is earnestly solicited.

Respectfully submitted:

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